

# DEVELOPMENT OF MATHEMATICS TEACHING MATERIALS BASED ON THE SCIENTIFIC APPROACH TO FACILITATE STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY IN STATISTICS LEARNING

Tasya Ananda<sup>1</sup>, Sehatta Saragih<sup>2</sup>, Elfis Suanto<sup>3</sup>

<sup>1-3</sup> Universitas Riau, Indonesia

[tasya.ananda3568@student.unri.ac.id](mailto:tasya.ananda3568@student.unri.ac.id)

**ABSTRACT** This study was motivated by students' low mathematical problem-solving ability, which was caused by inappropriate learning approaches and the lack of teaching materials that support the development of mathematical problem-solving ability. This study aims to produce mathematics teaching materials based on a scientific approach that are valid and practical to facilitate students' mathematical problem-solving ability in statistics material, specifically measures of central tendency, for Grade VIII SMP/MTs students. This research is development research using the Tessmer model, which consists of preliminary and formative evaluation stages, including self-evaluation, expert review, one-to-one evaluation, and small group evaluation. The instruments used were validation sheets and student response questionnaires. The results of validation by three experts showed that the teaching materials had a very high level of validity, with an average score of 87.4%. Readability and attractiveness tests through one-to-one evaluation, as well as practicality tests through small group evaluation involving 11 students, resulted in an average response score of 89.25%, which was categorized as very practical. These findings show that the developed teaching materials are feasible to use and can support the development of students' mathematical problem-solving ability. The contribution of this research lies in the explicit integration of the scientific approach into the structure of teaching materials to facilitate mathematical problem-solving ability. The implication of this research shows that developing teaching materials based on the scientific approach can be a strategic solution for improving the quality of mathematics learning at the junior high school level.

**Keywords:** mathematics teaching materials, scientific approach, mathematical problem-solving ability, statistics learning

**ABSTRAK** Penelitian ini dilatarbelakangi oleh rendahnya kemampuan pemecahan masalah matematis siswa yang disebabkan oleh pendekatan pembelajaran yang kurang tepat serta terbatasnya bahan ajar yang mendukung pengembangan kemampuan pemecahan masalah matematis. Penelitian ini bertujuan untuk menghasilkan bahan ajar matematika berbasis pendekatan saintifik yang valid dan praktis untuk memfasilitasi kemampuan pemecahan masalah matematis siswa pada materi statistika, khususnya ukuran pemusatan data, untuk siswa kelas VIII SMP/MTs. Penelitian ini merupakan penelitian pengembangan dengan

menggunakan model Tessmer yang terdiri atas tahap preliminary dan formative evaluation, meliputi self-evaluation, expert review, one-to-one evaluation, dan small group evaluation. Instrumen yang digunakan berupa lembar validasi dan angket respons siswa. Hasil validasi oleh tiga ahli menunjukkan bahwa bahan ajar memiliki tingkat validitas sangat tinggi dengan skor rata-rata 87,4%. Uji keterbacaan dan kemenarikan melalui one-to-one evaluation serta uji kepraktisan melalui small group evaluation yang melibatkan 11 siswa menghasilkan skor respons rata-rata 89,25% dengan kategori sangat praktis. Temuan ini menunjukkan bahwa bahan ajar yang dikembangkan layak digunakan dan dapat mendukung pengembangan kemampuan pemecahan masalah matematis siswa. Kontribusi penelitian ini terletak pada integrasi pendekatan saintifik secara eksplisit dalam struktur bahan ajar untuk memfasilitasi kemampuan pemecahan masalah matematis. Implikasi penelitian ini menunjukkan bahwa pengembangan bahan ajar berbasis pendekatan saintifik dapat menjadi solusi strategis dalam meningkatkan kualitas pembelajaran matematika di tingkat SMP/MTs.

**Kata-kata kunci:** bahan ajar matematika, pendekatan saintifik, kemampuan pemecahan masalah matematis, pembelajaran statistika

## INTRODUCTION

Mathematics learning is a process of interaction between students and educators in a deductive knowledge structure conveyed through symbolic language carefully, clearly, and accurately (Pujiastuti et al., 2021). In the Merdeka Curriculum, learning is focused on understanding concepts in depth and strengthening competencies through meaningful learning (Kemendikbudristek, 2021). This orientation demands the mastery of 21st-century skills, including mathematical problem-solving ability.

Mathematical problem-solving ability is a complex cognitive activity that requires appropriate solution strategies (Harahap & Surya, 2017) and serves as the basis of critical thinking in mathematics learning (Zuin et al., 2018). This ability is relevant to everyday life because almost all problems require reasoning and decision-making (Solomon & Croft, 2015). Critical thinking, problem solving, and decision-making are part of 21st-century learning outcomes (Trilling et al., 2017; McGrath & Fischetti, 2019). Therefore, mathematics learning needs to emphasize conceptual understanding, not merely procedural knowledge (Zaslavsky, 2019).

However, Indonesian students still have difficulty developing mathematical problem-solving ability due to the lack of connection between mathematics learning and real contexts (Nugraha & Basuki, 2021) and the lack of critical thinking training from an early age (Damayanti & Kartini, 2022). A contextualized approach can be a solution to link learning to students' lives (Clarke & Roche, 2018; Reyes et al., 2019), as problem solving also involves aspects of perception, memory, and social interaction (Nakakoji & Wilson, 2020). Marlina et al. (2018), Harahap and Surya (2017), and Ulvah Shovia (2016) emphasize that this ability is more developed in students who are actively involved in effective learning.

The low mathematical problem-solving ability of Indonesian students is also reflected in international assessment results. TIMSS and PISA data show the low ability of Indonesian students in solving non-routine problems that require reasoning

and generalization (Suraji et al., 2018; OECD, 2023). Similar conditions were found in junior high school students in Pekanbaru, especially in solving contextual questions on statistics material (Sriwahyuni & Maryati, 2022). These findings indicate the need for learning approaches and teaching materials that can support students in understanding concepts and applying them to problem-solving situations.

One alternative to overcome these problems is the scientific approach, which includes the steps of observing, questioning, reasoning, trying, and communicating. The scientific approach encourages active learning and the development of scientific skills. Unfortunately, this approach has not been optimally integrated into mathematics teaching materials in schools. In fact, the combination of scientific and contextual approaches has been proven to support students' analysis, strategies, and decision-making (Nurhidayati et al., 2017), as well as meaningful and independent learning (Fuada, 2019). Although many studies have discussed the scientific approach, the development of printed teaching materials based on this approach to facilitate mathematical problem-solving ability in statistics material at the junior high school level is still limited. This indicates a research gap that needs to be addressed.

In developing students' mathematical problem-solving ability, conceptual understanding also plays an important role. Conceptual understanding allows students to recognize similarities between situations and strengthens the transferability of knowledge (Mason, 2019), which should be instilled early (Simon, 2018). On the other hand, mastery of formulas does not guarantee success in solving problems without good conceptual understanding (Toksoy & Akdeniz, 2015). In addition to cognitive aspects, psychological factors such as self-efficacy also play an important role in mathematics learning because they are related to students' motivation, effort, persistence, and help-seeking behavior (Skaalvik et al., 2015).

Mathematical problem-solving ability is one of the main goals of mathematics learning because it is closely related to everyday life. Problem solving is at the core of mathematical activities (Polya, 2015), as it reflects the integration of knowledge, cognitive processes, and affective processes. Therefore, learning resources that are systematically designed to support students' conceptual understanding and problem-solving processes are needed.

Based on this background, this study aims to develop printed mathematics teaching materials based on a scientific approach for statistics material, specifically measures of central tendency, to facilitate the mathematical problem-solving ability of Grade VIII SMP/MTs students.

## **METHODS**

This research used a development research approach supported by qualitative and quantitative data to obtain a comprehensive picture of the development of mathematics teaching materials on statistics. Qualitative data were used to describe

the quality, readability, and practicality of the teaching materials, while quantitative data were used to measure validation results and student responses.

The research design used was a development model consisting of two main stages, namely the preliminary stage and the formative evaluation stage. In the formative evaluation stage, this study adopted the evaluation procedure designed by Tessmer, which includes self-evaluation, expert review, one-to-one evaluation, and small group evaluation.

The research subjects consisted of several groups according to the evaluation stages. At the one-to-one evaluation stage, the subjects involved three students who were purposively selected to assess the readability and ease of use of the teaching materials. Furthermore, at the small group evaluation stage, the subjects consisted of 11 Grade VIII students who were also purposively selected to test the practicality of the teaching materials on a broader scale. The selection of subjects was carried out by considering the heterogeneity of academic ability and the relevance of students' experience with statistics material.

Data collection instruments consisted of interview sheets, observation sheets, teaching material validation sheets, and student response questionnaires. The validation sheet was used by validators, namely mathematics lecturers, to assess the suitability and quality of the teaching material content. Meanwhile, the student response questionnaire was used to collect quantitative data regarding the practicality and attractiveness of the teaching materials from the students' perspective. Qualitative data were obtained from interviews and observations containing narratives and descriptive feedback.

Qualitative analysis was carried out by describing categories and patterns of information obtained from interviews and observations. Quantitative analysis was carried out using simple statistical calculations based on the questionnaire data and validation sheets. The data analysis techniques included validity analysis and practicality analysis. Product validity was examined through expert validation, while the consistency of findings was strengthened through triangulation of data sources by comparing expert validation results, observations, and student responses. The data analysis technique used to analyze validation data was adapted from Akbar (2017) as follows:

$$V_a = \frac{TS_a}{TS_h} \times 100\%$$

Description:

$V_a$  : Percentage validation score

$TS_a$  : Total score obtained

$TS_h$  : The highest total score possible

The validity analysis criteria used can be seen in Table 1 (Akbar, 2017).

**Table 1.** Criteria for Validity of Teaching Materials

Interval	Category
$85.00\% < V_a \leq 100.00\%$	Very Valid
$70.00\% < V_a \leq 85.00\%$	Valid
$50.00\% < V_a \leq 70.00\%$	Less Valid
$01.00\% < V_a \leq 50.00\%$	Not Valid

The practicality analysis was also adapted from Akbar (2017) using the following formula:

$$V_p = \frac{TS_p}{TS_h} \times 100\%$$

Description:

$V_p$  : Percentage score from the questionnaire

$TS_p$  : Total score obtained from users

$TS_h$  : The highest total score possible

**Table 2.** Criteria for Practicality of Teaching Materials

Interval	Category
$85.00\% < V_p \leq 100.00\%$	Very Practical
$70.00\% < V_p \leq 85.00\%$	Practical
$50.00\% < V_p \leq 70.00\%$	Less Practical
$01.00\% < V_p \leq 50.00\%$	Not Practical

## FINDING AND DISCUSSION

The product developed in this study is a printed mathematics teaching material for statistics, specifically the topic of measures of central tendency. The teaching material was designed based on the scientific approach and organized through learning activities that guide students to observe, ask questions, collect information, reason, and communicate their ideas. These stages were integrated into contextual problems to facilitate students' mathematical problem-solving ability.

The developed teaching material contains explanations, contextual activities, guided problem-solving tasks, and exercises related to mean, median, and mode. The material was arranged to help students understand statistical concepts not only through formulas, but also through problem situations that require interpretation,

strategy selection, and conclusion drawing. The cover of the developed teaching material is presented in Figure 1.



Figure 1. Cover of the Developed Mathematics Teaching Material

After the teaching material was developed, it was evaluated through the formative evaluation stages, including self-evaluation, expert review, one-to-one evaluation, and small group evaluation. The expert review was conducted by three validators to assess the feasibility of the teaching material in terms of graphics, content, presentation, language, scientific approach, and mathematical problem-solving ability. The validation results are presented in Table 3.

Based on the results of validation by three expert validators, the developed teaching materials obtained an overall average score of 87.40%, which is categorized as very valid. The validation covered six aspects, namely graphics, content, presentation, language, scientific approach, and mathematical problem-solving ability. The detailed validation results are presented in Table 3.

Table 3. Teaching Material Validation Results

Aspects Assessed	Validator 1 (%)	Validator 2 (%)	Validator 3 (%)	Average (%)	Category
Graphics	89.29	86.90	88.10	88.09	Very Valid
Content	88.89	88.89	88.89	88.89	Very Valid
Presentation	85.42	86.46	86.46	86.11	Very Valid
Language	86.11	84.72	86.11	85.65	Very Valid

Aspects Assessed	Validator 1 (%)	Validator 2 (%)	Validator 3 (%)	Average (%)	Category
Scientific approach	85.00	86.67	86.67	86.11	Very Valid
Mathematical problem-solving ability	89.58	89.58	89.58	89.58	Very Valid
<b>Average</b>	<b>87.38</b>	<b>87.20</b>	<b>87.63</b>	<b>87.40</b>	<b>Very Valid</b>

The validation results indicate that the teaching materials met the criteria of validity in all assessed aspects. The highest score was obtained in the aspect of mathematical problem-solving ability, with an average of 89.58%. This shows that the structure, tasks, and learning activities in the teaching materials were considered appropriate for facilitating students' mathematical problem-solving ability. The content aspect also obtained a high score of 88.89%, indicating that the material presented was suitable for statistics learning, particularly measures of central tendency. Meanwhile, the scientific approach aspect obtained an average score of 86.11%, which shows that the teaching materials had integrated the stages of observing, questioning, collecting information, reasoning, and communicating in a valid manner.

The small group trial showed that the teaching materials obtained an overall practicality score of 89.25%, which is categorized as very practical. The practicality assessment was based on students' responses to the ease of use, understanding of the material, suitability to students' needs and conditions, and appropriateness of the scientific approach. The detailed results are presented in Table 4.

**Table 4.** Results of Students' Response Questionnaire on Teaching Materials

Aspects Assessed	Validator 1 (%)	Validator 2 (%)	Validator 3 (%)	Average (%)	Category
Ease of use of teaching materials	93.18	93.18	93.18	93.18	Very Practical
Understanding of teaching material	91.48	85.80	85.80	87.69	Very Practical
Suitability of teaching materials to students' needs, interests, and conditions	89.61	87.34	88.96	88.64	Very Practical
Appropriateness of the scientific approach in teaching materials	91.36	87.27	87.73	88.79	Very Practical

Aspects Assessed	Validator 1 (%)	Validator 2 (%)	Validator 3 (%)	Average (%)	Category
Average	91.20	88.00	88.54	89.25	Very Practical

The practicality results show that the developed teaching materials were easy to use and understandable for students. The highest score was found in the ease of use aspect, with an average of 93.18%. This indicates that the layout, instructions, and learning activities in the teaching materials were considered accessible by students. The aspect of understanding the teaching material obtained an average of 87.69%, which shows that students were able to follow the explanations and activities provided in the material. In addition, the suitability of teaching materials to students' needs, interests, and conditions obtained a score of 88.64%, indicating that the teaching materials were relevant to students' learning characteristics.

The high validity and practicality results indicate that the developed teaching materials have met the quality standards in terms of content, presentation, language, scientific approach, and usability. These results suggest that the integration of the scientific approach in the teaching materials is relevant for facilitating students' mathematical problem-solving ability in statistics learning. However, because this study focused on validity and practicality, the findings should be interpreted as evidence of feasibility and practicality, not yet as evidence of effectiveness in improving students' mathematical problem-solving ability.

These findings are in line with Asmaranti et al. (2018), who emphasized that the scientific approach through the stages of observing, questioning, collecting data, reasoning, and communicating can help students develop logical thinking and problem-solving processes. In the teaching materials developed in this study, these stages were explicitly embedded in the learning activities so that students were guided to understand problems, identify relevant information, select appropriate strategies, and communicate their solutions.

The findings are also consistent with Sriwahyuni and Maryati (2022), who emphasized the importance of problem-based learning strategies in supporting mathematical problem-solving ability. However, these findings differ from Lia Kurniawati (2022), who stated that the application of the scientific approach did not significantly improve mathematical problem-solving ability when it was not supported by contextualized teaching materials. This difference may be related to the suitability of teaching materials with students' characteristics and the school context.

In this study, the teaching materials were designed by considering the characteristics of Grade VIII students and the nature of statistics material. The use of concrete and contextual examples in measures of central tendency was intended to help students

connect mathematical concepts with real-life situations. This is important because mathematical problem-solving ability requires not only procedural knowledge, but also conceptual understanding and the ability to select appropriate strategies in a given context.

This research contributes to the development of mathematics teaching materials based on the scientific approach that are oriented toward facilitating mathematical problem-solving ability. Practically, the teaching materials can be used by teachers as an alternative learning resource that is structured, contextual, and aligned with the stages of the scientific approach. Theoretically, this research strengthens the relevance of the scientific approach in supporting meaningful mathematics learning, particularly in statistics topics that require reasoning, interpretation, and decision-making.

Although the developed teaching materials met the valid and practical criteria, this study still has limitations. The product has not yet integrated interactive media or digital platforms that can increase flexibility in hybrid or technology-supported learning contexts. Therefore, further development may involve the integration of interactive learning videos, digital quizzes, or Learning Management System (LMS)-based platforms. In addition, the small group trial involved a limited number of students. Further research with a broader sample and various school contexts is recommended to examine the effectiveness and broader applicability of the developed teaching materials.

## **CONCLUSIONS AND RECOMMENDATIONS**

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Based on the results and discussion, it can be concluded that the developed statistics teaching materials based on the scientific approach are valid and practical for facilitating students' mathematical problem-solving ability. This is shown by the expert validation results, which reached an average score of 87.40% in the very valid category, and the student response results in the small group evaluation, which reached an average score of 89.25% in the very practical category. These findings indicate that the teaching materials are feasible to use in statistics learning, particularly on the topic of measures of central tendency.

The developed teaching materials provide learning activities that guide students through the stages of observing, questioning, collecting information, reasoning, and communicating. Therefore, these materials can be used as an alternative learning resource that supports the implementation of the scientific approach in line with the Merdeka Curriculum. However, this study was limited to validity and practicality testing, so the effectiveness of the teaching materials in improving students' mathematical problem-solving ability still needs to be examined further. Future research is recommended to conduct wider trials in diverse school contexts and to develop the teaching materials by integrating interactive digital media to increase their attractiveness, flexibility, and usability in technology-supported learning environments.

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